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Home Automation with Remote Monitoring: Design of a Hybrid Model for Internet of Things Technology

Author
MUTIJIMA Asher Emmanuel, Msc.IT
B&IT Faculty, University of Tourism Technology and Business studies

Co-Author
Dr. Mbanzabugabo Jean Baptiste, PhD.
Dean of Faculty, University of Tourism Technology and Business studies

Abstract:- This paper discusses IoT technologies for smart home implementation while elaborating home automation and remote monitoring models and as to improve them, researcher developed a hybrid model for IoT technologies which converges the model of home automation and remote monitoring. This study is a qualitative by design; it used interview guide to gather primary data which he analysed and interpreted based on objectives of this study, researcher also consulted secondary enhance meaning of the findings. Researcher conducted impact analysis to examine existing models smart devices contribution in the effectiveness running of smart home. Researcher adopted desk research approach to studyscholars and industry experts' publications in smart homes development and implementation. To address problems encountered when deploying smart homes using two different models for home automation and remote monitoring separately, researcher designed a hybrid model to cater for an incompatibility issues, security and divergence issues while introducing convergence, ensuring securityand easability to use. Smart home technologiesthat are currently used in smart homes were studied and results into a hybrid model development to address gaps identified in existing separate models for home automation and remote monitoring. Researcher recommendedthe proposed model to smart home developers and home owners.

Keywords:- *IoT, Smart home, Convergence, hybrid, model.*

I. INTRODUCTION AND BACKGROUND

Home automation systems they are collections of smart devices that allow various functions in a home or working premises, for example light and outlet control, energy monitoring, temperature measurement, air conditioning and heating, etc. Typically, these devices are smart sensors that are deployed with a protocolof low-power communication. Remote monitoring is an ideal way of controlling one's property access remotely. (CHENG, 2015)

The home automation concept has been around for a while; according to an article by (Somfy, 2018) discussing the history of home automation. In 1898, Nikola Tesla invented the first remote control to operate a boat toy. Tesla found a way to use radio waves to send command to his boat from a portable device. In 1901 to 1920 there domestic appliances were rapidly developed, first home appliances were invented and those revolutionized the lives of domestic maids.

After many years of advances in computing and electronics development, the first ever smart device - the ECHO IV - was born. This machine could monitor temperature and home control appliances only. The clapper was an electrical switch that was invented in 1996 and was operated by sound, usually clapping (although coughs, barking dogs or a door can be accidentally hit).

Home automation started to rise in popularity in the late 1990s and early 2000s as internet technology developed rapidly and later became a more affordable alternative. Domestic technology was greatly discussed as home appliances were being integrated with computers. The Millennium House was a British show-house opened in 1998 to show how home automation can be done with computer controlled heating, security, lighting, gardens and doors. (Somfy, 2018)

As the technology boom of the 1990s improved the sophistication of networking technologies, and the sophistication of these systems also increased. Remote monitoring has become more complex, gathering more data and incorporating Internet-based technologies to access off-site and / or off-site personnel, (Cramer, 2014).

According to a publication by (ITU, 2019),the implementation of IoT technologies is expected to connect some 50 billion devices to the network by 2020, affecting almost every aspect of our daily lives. IoT contributes to the convergence of industrial sectors and SG20 provides the specialized standardized IoT platform needed for this convergence to be based on an integrated set of international standards.

As revealed by (Bradley, Barbier , & Handler, 2013), in Republic of South Africa; smart home technology grows, homeowners' awareness about energy utilization. The homeowners are willing to learn; better access to resource utilization by homeowners leads to lower consumption and smart home technology translates into a higher standard of living for homeowners. As part of this study, researcher learned that South Africans' homeowners require to know that if they do not adopt smart home technology to improve the management of their homes, they will ultimately pay the inefficiency of the current traditional methodologies used for their home management. The study findings also suggested that industry experts need should continue to

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inform homeowners about the multiple benefits of technology for smart homes. They must also inform the public to raise public acknowledgment of smart home technology, the key recommendation being is implementation of automation within homes.

The African agenda as stated in the (SmartAfrica, 2017), Connecting everything through Internet of Things (From washing machines, fridges, microwaves, cars, TV sets, etc…) so as to encourage implementation of smart cities and communities which is designed to accelerating the realization of smart Africa strategic vision.

In recent years, Rwanda has demonstrated enormous development in many areas such as information technology and innovation. According to Rwanda's 2020 Smart Master Plan, IoT has been highlighted as an important pillar to improve country's development in the coming years[1]

According to (Tuyishimire, Mukayisenga, Aminata, Saint, & Deen, 2017), the IoT has seen tremendous growth globally and is changing business in numerous industries. Rwanda is among the leading technology adopters in Africa, however, the government of Rwanda (GoR) has not yet implemented IoT policies and according to findings in (Development of Internet of Things Indicators in Rwanda Based on Stakeholder Analysis, 2017) there are no defined indicators to demonstrate the readiness of Rwanda to accommodate IoT.

According to(Panwar, Maurya, Rawat, Kanswal, & Ranjan, 2017), home automation is an everyday business, given the benefits it provides. Home automation can be obtained by connecting household appliances, electrical appliances to the Internet or to cloud storage. The demand for network home automation has increased in recent days due to its simplicity and affordable price. Cloud-based platforms help connect to what belongs to a person so that it is easy for anyone to access anything and everything at any time and in a friendly place using defined portals . In this architecture, the cloud acts as a front end to access a system that can control devices via a wireless network-based approach.

With a smart home system, various sensors are connected with smart devices whose functions differ but serve to ease access for users. Users can control their devices from their smartphones, tablets, home or away computers.

In an interview (Commeignes, 2016)revealed that from the system perspective, a home automation system The distributing business will provide a cloud-based server in their smart home automation systems products and is made, users can control their devices from a smartphone or tablet when and wherever they might be. However, communication with the cloud server is compulsory in a home automation system architecture.

The advancement of technology has contributed to the changing concept of security in modern homes. It has changed from a simple lock and key security concept to implementing sophisticated security systems using CCTV cameras, microphones, motion detectors, alarms, silent alarms, etc. By connecting modern homes to the Internet which is very popular today, users can access and control their homes remotely at any time and from anywhere in the world.(Jose & Malekian, 2015)

(Cramer, 2014); It has been argued that remote terminal units (RTUs) are linked to utilities in some of the earliest technological applications. These early systems operated on ground communication systems such as LAN lines or over telephone wires and are often simple warning systems. Publications reveals that Today's technology enables remote monitoring and home automation. Those in charge for the monitoring systems can connect from wherever and not only check status, but also make logical modifications and updates.

Innovations in collection ofdata, storage and transmission have led to some capabilities as well in remote monitoring. According to Cisco's 2013 white paper, greater amounts of data and information can be collected, allowing for a better and vivid picture of the entire operation.

"We think this is not suitable for most situations. For example, it is possible to crease the Internet connection in a user's home. The architecture implies that; user cannot command his devices, even if in his own house", (Commeignes, 2016).

Findings by (Tuyishimire, Mukayisenga, Aminata, Saint, & Deen, 2017) reveals that to encourage deployment, the smart citizens are willing to pay for IoT services and smart home devices as long as the cost is reasonable.

Sustainable development goals' achievement encompass realization of smart cities whereby smart homes are key enabler of connected smart villages where information access and sharing will be made easier while promoting convenience and comfort of home owners

(Abdulrahmana, Isiwekpeni, Surajudeen-Bakinde, & Otuoze, 2016)reveals the need for future research on simplified design protocols for developing a robust home automation system to deal with the problems of complexity, multiple incompatible standards and the resulting expenses in the existing systems' models.

Various technologies used for home automation discussed in this paper include context-sensitive home automation systems, centralized home automation systems based on controllers, home automation systems based on Bluetooth, the Global Mobile Communications System or mobile home automation systems. automation systems based on the home short message service, home automation systems based on the general radio communication service, dual-tone home automation systems and Internet-based home automation systems.

[1]Smart Rwanda 2020 master plan: Towards a knowledge based society, 2015. Ministry of Youth and ICT

A. Statement of the problem

Developers of smart home automation systems implement models for home automation to cater for home connected devices but they are subject toadopt side models for remotely monitoring this automated home system(Hossain, Nazmul & Hossain, Md. Alam & Sultana, Rafia & Lima, & Farzana, 2018).However, keeping these two models separate raises difficulties in implementing a smart homes solutions. Some developers easily access and implement home automation models and later smart home owners find themselves struggling to implement remote monitoring system which comes with additional costs when try to migrate it in a home automation system.

Technologies that are being used in the implementation of smart homes differ from each other with raise a problem of technology incompatibilities when implementing a remote monitoring system for an established home automation system. Incompatibility discussed here involve lack of signal translation; signal from different sources (technologies) into a uniform signal language. Incompatibility also comes as a results for Lack of impact analysis of IoT technologies of home automation model and remote monitoring.

B. Objectives of the study

- To study technologies and models currently being used for smart homes with IoT technology
- To conduct the impact analysis of IoT technology for home automation and remote monitoring
- To design a hybrid model for home automation with remote monitoring using IoT technology

II. LITERATURE REVIEW

A. Theoretical framework

➢ *Smart and home, a convergence theory*

Data security, the place of control at home and the extent to which smart homes provide better understanding and capacity of occupants and the efficiency of the system are some of the main issues raised in the smart home literatures.(Darby, 2016)

Table 1: Types of smart home study and what they can tell us

Study type, with examples	What they tell us	Comments
Conceptual (Green and Marvin 1994; Wilson et al., 2015)	Meanings ascribed to smartness; situating technologies in relation to time, space, activities, agendas and actors.	Reflecting on the ideas and potentials for different smart configurations, these should be read in conjunction with the other types of study.
Technical (Wu, Liao and Fu, 2007; Rashidi and Cook, 2009)	How system elements can communicate with each other; what a system looks like; algorithms to optimize system efficiency.	The largest single category, dealing with aspects of design, interoperability, system security etc. Generally optimistic in tone.
Prospective (Balta-Ozkan et al., 2013; Skølsvold and Ryghaug, 2015)	How smart homes might fit within smart systems; what types of smart systems are possible and how they might be configured and operated.	While technical issues are often foremost, these studies set out or imply scenarios that include some 'home' issues: for example, user priorities, willingness to cede control.
Evaluative (Christiansen and Andersen, 2013; Woodruff et al., 2007; Nyborg and Røpke, 2013)	How smart homes work in practice (routines, meanings, tech and knowledge), including relational aspects and functionality.	Few in number, but important in order to assess how smart technology might work in particular contexts.

Source: Secondary Data

As the figure below indicates, only conceptual and (qualitative) evaluative studies typically address all four sets of Home meanings. Technical and prospective studies both tend to emphasize control, with prospective analysis taking relationships between actors into account to some extent. The figure indicates how some aspects of Home may be side-lined in smart home discourses, especially the more technical accounts.

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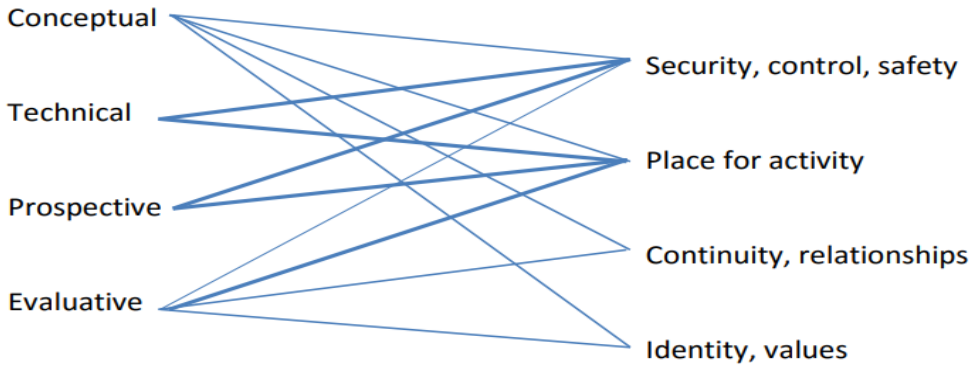

Fig. 1: Different types of smart home study and the elements of home life that they tend to prioritize

B. Technologies Used For Home Automation

Various home automation technologies to be considered include context-aware home automation systems, central controller-based home automation systems, Bluetooth-based home automation systems, Global System for Mobile communication or mobile-based home automation systems, Short Messaging Service-based home automation systems, General Packet Radio Service-based home automation systems, Dual Tone Multi Frequency-based home automation systems, and Internet-based home automation systems (Jose & Malekian, Smart Home Automation, 2015).

- *Smart Home systems*

The Home Automation field is expanding rapidly as electronic technologies converge. The home network encompasses communications, entertainment, security, convenience, and information systems. (Robles & Tai-hoon, 2010)

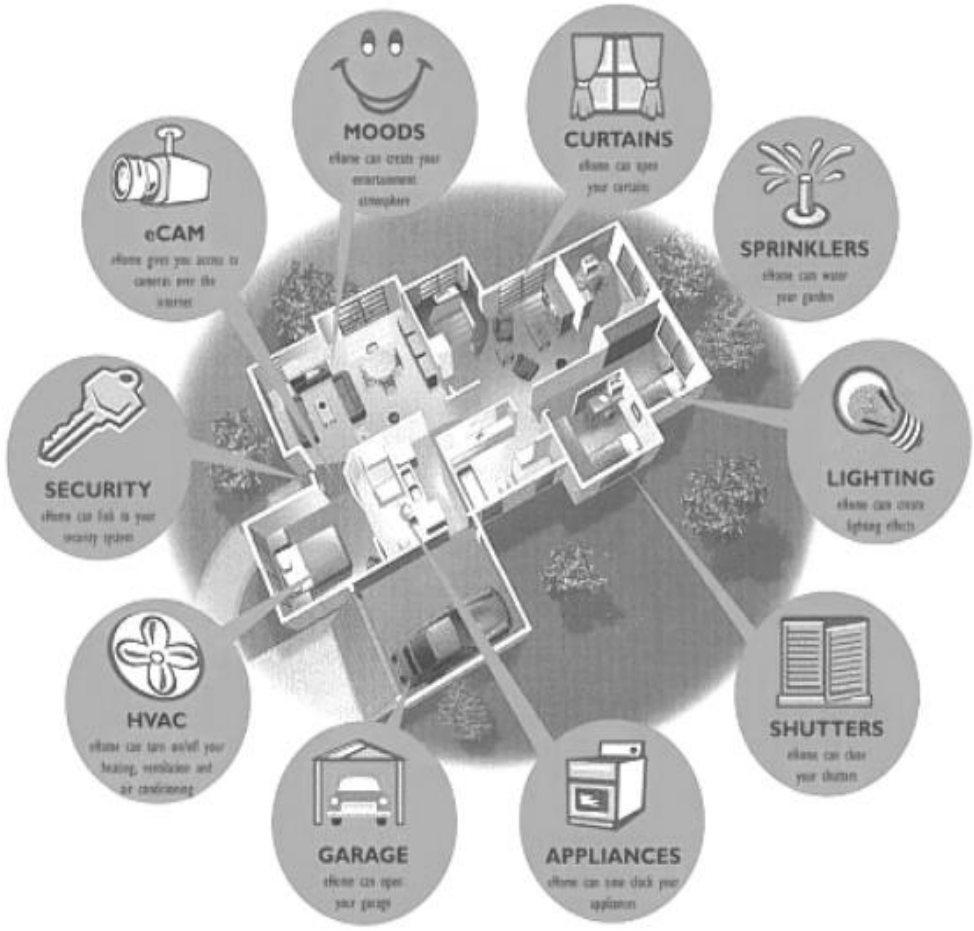

Fig. 2: Smart Home Technology Automation

Source: Secondary Data

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- **Z-Wave technology:** Z-Wave uses a Source Routing Algorithm to determine the fastest route for messages. Each Z-Wave device is embedded with a code, and when the device is plugged into the system, the network controller recognizes the code, determines its location and adds it to the network. When a command comes through, the controller uses the algorithm to determine how the message should be sent. Because this routing can take up a lot of memory on a network, Z-Wave has developed a hierarchy between devices: Some controllers initiate messages, and some are "slaves," which means they can only carry and respond to messages.
- **Alexa/google-home:** An Alexa enabled device like Google Home device, you can have your own personal assistant. With simple voice commands, you can get information about traffic, sports, finance and more. Google Home allows you stream videos directly to your television, set alarms, play music and ask for directions all from the comfort of your own home. It can retrieve your flight information, set alarms and timers, and tell you about the traffic on your way to work. Voice-Control Your Smart Devices the Google Home connects with smart devices in a smart home, so you can use your voice to set the perfect temperature or turn down the lights. Multi-Room Capability Multiple Google Home devices can be grouped together to enjoy the same content in every room.
- **ZigBee technology:** The name ZigBee reflects the concept of a mesh network due to messages from the transmitter in a zigzag like bees, in search of the best path to the receiver. While Z-Wave uses proprietary technology to operate its system, the ZigBee platform is based on the standard established by the Institute of Electrical and Electronics Engineers (IEEE) for personal wireless networks. This means that any business can create a ZigBee-compatible product without paying a license fee for the technology behind it, which could ultimately give ZigBee a market advantage. Like Z-Wave, ZigBee has fully functional devices (or those that direct the message) and reduced-function devices (or those that do not).
- **Insteon technology:** A wireless network provides more flexibility for mounting devices, but like power lines, they can be disruptive. Insteon provides your home network with a means of communication via electrical wires and radio waves, making it a double mesh network. If the message does not get through on one platform, try the other. Instead of routing the message, the Insteon device will broadcast the message, and all devices will take the message and broadcast it until the command is executed. The devices act as a peer, rather than one serving as a promoter and another as a receptor. This means that the more Insteon devices installed on a network, the louder the message(Edmonds & CHANDLER).
- **Installing a Smart Home:** Z-Wave, X10, Insteon and ZigBee just provide the technology for smart home communication. Manufacturers have made alliances with these systems to create the products that use the technology. Here are some examples of smart home products and their functions.(Darby, 2016)

✓ Cameras to follow the exterior of your house even if it is black outside.
✓ Plug a table lamp into a dimmer instead of the wall outlet, and you can make it brighter and more dim by pressing a button.
✓ A videophone at doors offers more than just a doorbell, you get a picture of the people at the door.
✓ Motion detectors send an alert when you move around your home and can even tell the difference between pets and burglars.
✓ Door handles can be opened with scanned fingerprints or a four-digit code, eliminating the need to search for house keys.
✓ Audio systems distribute music from your stereo to any room with connected speakers.
✓ Channel modifiers take any video signal from a security camera to your favorite TV station and are visible on all TVs in the house.
✓ Remote controls, keys and card controllers are the way to activate smart home applications. Most of these devices come with built-in web servers that allow you to access their information online.

Note: To address the incompatibility issues, Products using the same technology should work together despite different manufacturers, but joining up an X10 and a Z-Wave product requires a bridging device.

Researcher learned that when designing a smart home, you can do as much or as little home automation as you want. You could begin with a lighting starter kit and add on security devices later.

In an interview with on smart home developers in the city of Kigali, he estimated to the researcher that his clients spend between 150,000 Rwandan Francs and 8,500,000 Rwandan Francs for systems that are sophisticated. If the smart home is built gradually, starting with a basic lighting system, it may only be a few thousand Rwandan francs.

C. REVIEW OF EXISTING MODEL

➢ *IoT home automation model*

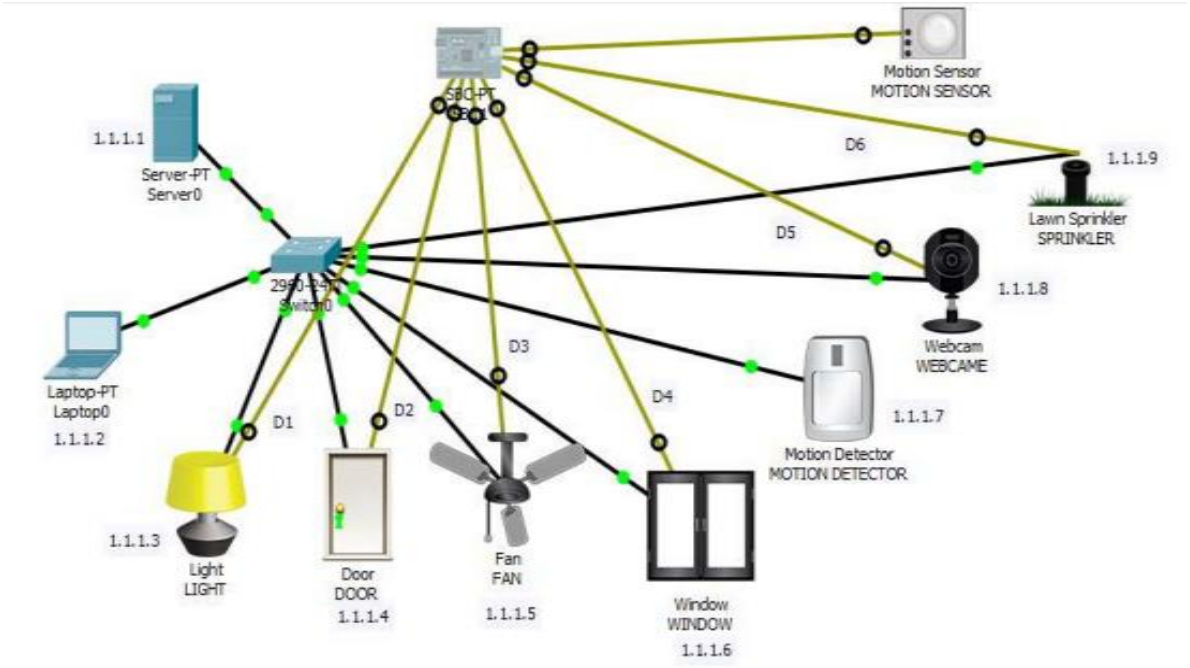

Fig. 3: Home automation system model

Illustrated by(Hossain, Nazmul & Hossain, Md. Alam & Sultana, Rafia & Lima, & Farzana, 2018), a Single Board Computers (SBC) is one kind of network access component. In that component, we connect motion sensor and others household objects like as door, fan, light, window, etc. Sensors are necessary to gain real-time data from things. These sensors rapidly create a huge volume of data. The main thing is to make a home automation system based on the Internet of Things idea composed of a main controlling instrument and all objects connected to the sensors.

In addition, with SBC board we will describe the system configuration for detecting the motion sensor. While

- Light ON/OFF
- Fan ON/OFF
- Door ON/OFF
- Sensors (motion detectors) ON/OFF
- Door Access ON/OFF
- Fire-Alarm/Sprinkler ON/OFF, and more as illustrated above

The goal of the discussed home automation model is not to formless imply costly objects such as high-end own computers, rather, to allows approved house masters to control associated instruments at home.

- **Research gap**

However, too much data are generated by these connected devices with a probability of false alarms which might inconvenience users/home owners. A programmable single board computer with a data engine would serve an importance of filtering data/signals/ streams from the connected then only alert the user/home owner on sensitive alarms thereafter execute appropriate command.

a man enters in the automated room, a motion is captured, so the sensor is alarmed for obtaining products activation. When it finds out any motion, then automatically all the objects turned ON/OFF. Whereas the sensor will rotate ON it shows high input after finishing its delay (1000ms) time it naturally closed OFF. This process happens continuously until motion object present in the existing home. (Hossain, Nazmul & Hossain, Md. Alam & Sultana, Rafia & Lima, & Farzana, 2018)

The home automation system in the model above has the abilities to observe the following objects in users home and monitor the following activities:

Alone, such a model for home automation would not promote easability and accessibility to home owners when away for home. Lack of a home network gateway to internet then to cloud servers, discourage remote access to home.

Researcher will reengineer the home automation model so as to cater for missing components in order to promote convenience and introduce remote access via internet.

➢ *REMOTE MONITORING MODEL*

The below figure, illustrates a home environment that is remotely monitored using an android smartphone/tablet. In a smart home environment simulation; power outlets, room temperature devices, door access, lights and electricity “watt” meter are connected using an Arduino Ethernet server which then connects to internet through router that also serves as a gateway to internet via which the smartphone/tablet devices can access the home environment.

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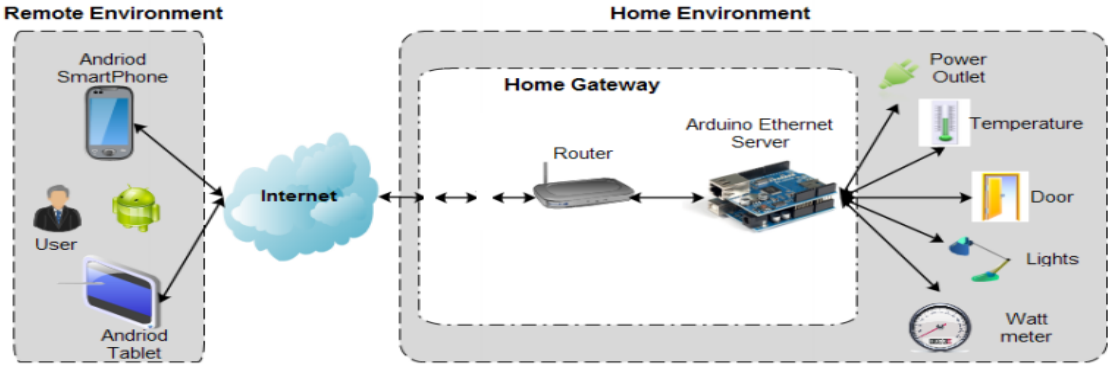

Fig. 4: conceptual design of home automation simulation

- **Research Gap**

Lack of firewall security mechanisms on the home network gateway, poses a security risk which can lead to intruders and remote unauthorized access.

Lack of a data engine in a remote monitoring model, would cause inefficiency in terms of command execution because there are no data stored (data about actuators' signals) , processed to help user monitoring remotely making informed decisions.

Also lack of a cloud server raises a concern on the storage of voluminous data generated in abundance by home connected devices.

Researcher will cater for the identified research gap while introducing models' convergence in his new model to propose for home automation and remote monitoring.

- **Compatibility, Safety and Security**

Safe access and security are important elements in any home. Home automation should cater for security by allowing only resident with credentials to the home gate-way portal. Via an API for a home automation a resident can lock the doors and windows and set the security system with a simple key press. Access control component allows residents to better monitor who comes in and out of their home and the common areas shared by allresidents.(CISCO, 2013)

Researcher have learned that with the Cisco Smart+Connected Video Door Station, when a neighbor rings thedoorbell, the resident can see who is at the door using their portable tablet or in-wall display, and let them in. researcher is willing to integrate this component in his system.

Clause 7 of ISO/IEC 30141:2018 offers the characteristics of IoT systems. Functions based on all or part of these attributes can be implemented in IoT systems. Some of these characteristics are functional, such as network connectivity, while others are non-functional, such as availability and compliance.

The below Table summarizes characteristics of an IoT model.

Table 2: Trustworthiness characteristic of IoT systems

Categories	Related characteristics
7.2 IoT system trustworthiness characteristics	7.2.2 Availability
	7.2.3 Confidentiality
	7.2.4 Integrity
	7.2.5 Protection of personally identifiable information
	7.2.6 Reliability
	7.2.7 Resilience
	7.2.8 Safety

Source: secondary data

Trust worthiness is defined in ISO/IEC 20924 as the degree of confidence a stakeholder has that the system performs as expected with characteristics including safety, security, privacy, reliability and resilience in the face of environmental disruptions, human errors, system faults and attacks.

The separation of functional and management capabilities means that the interfaces and functional capabilities of an IoT component, such as an IoT device, are completely separate from the management and capability interfaces of the component. This usually means that the management interface on an endpoint is different from the interface of the applied interface[2]

D. CONCEPTUAL FRAMEWORK

The relationship between IoT technology which is independent variable and smart home which dependent; can be conceptualized as illustrated below, and with the intervention of intervening variables, we obtain a framework that describes the final outcome which is a smart home remotely monitored using IoT technology.

[2]ISO_IEC_30141_2018(E)-Internet of Things (IoT)_Reference Architecture

ISSN No:-2456-2165

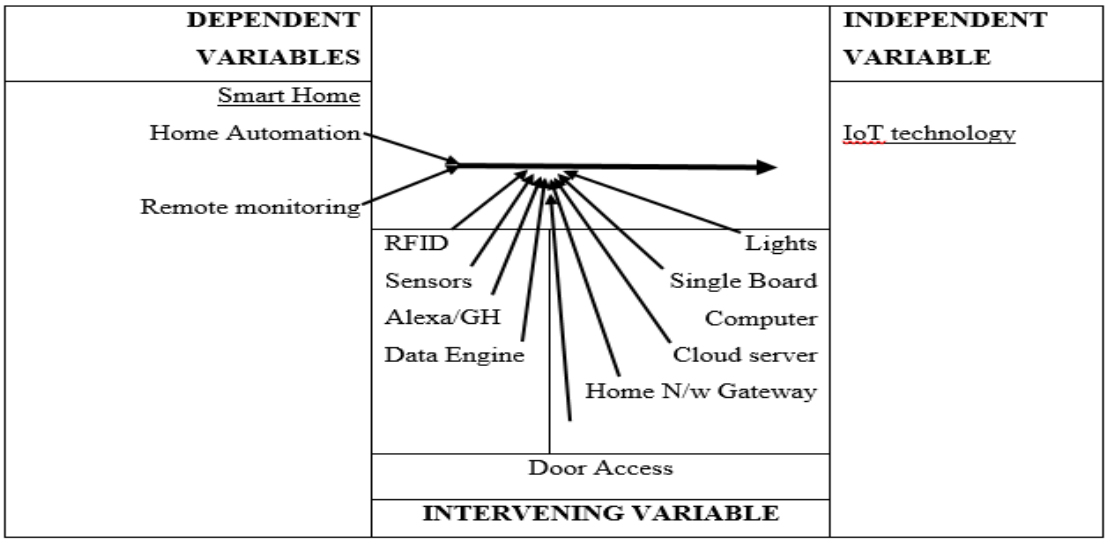

Fig. 5: Conceptual Framework

Researcher overcame the revealed research gap by designing a hybrid model which addressed the problem of incompatibility, IoT technology convergence and security which rise with the use of different technologies for remote monitoring a smart home; the proposed model provides signal translation feature at the home gateway whereby any signals from whichever manufacturer device will be translated into a one signal that can be understood for command execution. Existing models do not cater for signal translations, rather, they promote incompatibility with the connected devices and probable security.

The model researcher propose,it guarantees a more secure access authorization by providing a authentication to address security concerns of smart home developers and home owners, a concern that is rapidly growing with the hacking technology advancements. Existing models, as elaborated previously, only cater little for security concern.

III. RESEARCH METHODOLOGY

The researcher adopteda qualitative approach which is concerned phenomenon and is aiming at discovering underlying motives and desires, using interviews guide and secondary data for the purpose. A research design aims at finding a solution for an immediate problem facing a society or an industrial/business organization, (Kothari C. R., 2004).Researcher consulted secondary data and experts publications on the subject being studied. Desk research used to gather facts and experts opinionsthat would lead to answering research questions. It's best to conduct desk research in a structured manner, as a great deal of information is available.(Dingemanse, 2019)

The qualitative study stems mainly from the research questions developed in this research which are used as a means to highlight the key problems under study and to broaden the researcher's knowledge of the case areas. Likewise, this research follows a qualitative interpretative approach framed by a recognition of the philosophy according to which knowledge is socially constructed and that there can be several perspectives on the same subject.(Kabera, 2013).

This research aims at understanding the phenomena within the scope of this study in order to develop conceptual insights rather than test a hypothesis (Novella et al., 2008).

The target populationwas smart home owners/tenants and smart home developers in the city of Kigali Rwanda. Researcher gathered data from this population, data that would contribute to answering the research questions.

The samplesize consisted of 40 made of 15 smart home developers and 25 smart home owners/tenants residing in the vision city estate in Kigali city.

Researcher used convenience sampling which is a non-probability sampling technique where subjects are selected because of their convenient accessibility and proximity to the researcher. A convenience sample is either a collection of subjects that are accessible or a self-selection of individuals willing to participate.

IV. MODEL DESIGN, TESTING AND ANALYSIS

Home automation with remote monitoring consist the broad picture of a full smart home that can be controlled, accessed and manipulated with or without home tenants presence, however, there are concern about security, compatibility and technology convergence. For a full smart home free from uncertainty, a hybrid model was developed to bridge the gap identified in existing models.

With the new proposed design; researcher used Cisco Packet tracer 7.1 to build a model and simulate an environment running a smart home with two different networks but which interrelate to allow remote monitoring. Security and compatibility was attended toby putting in place a security firewall, deploying a data engine for data processing and Alexa at home hub SBC to ensure compatibility of smart devices. Also smart devices were connected home LAN and remotely controlled via home gateway.

A. Hybrid Model design

Research Gap	Solution	Added Value proposition	Methodology
Too much data generated by connected devices with a probability of false alarms which inconvenience home owners/tenants.	A programmable single board computer with a data engine would serve an importance of filtering data/signals/ streams from the connected then only alert the user/home owner on sensitive alarms thereafter execute appropriate command.	IoT technology convergence which promotes technological compatibility	Consult industry experts publication on IoT technology for smart homes
Lack of a home network gateway with easy access remote monitoring through ISP BSC.	Reengineer the home automation model to cater for missing components for easy remote access via internet.	Enhanced convenience with the introduction of Alexa/google-home enabled smart devices to increase convenience in a smart home	
Lack of firewall for network security can lead to intruders and remote unauthorized access.	Introduce firewall at home gateway/data server to ensure only authorized traffic.		Simulate the implementation of a hybrid model for home automation and remote monitoring in CISCO packet tracer 7.2.1

Fig. 5: Hybrid Model design

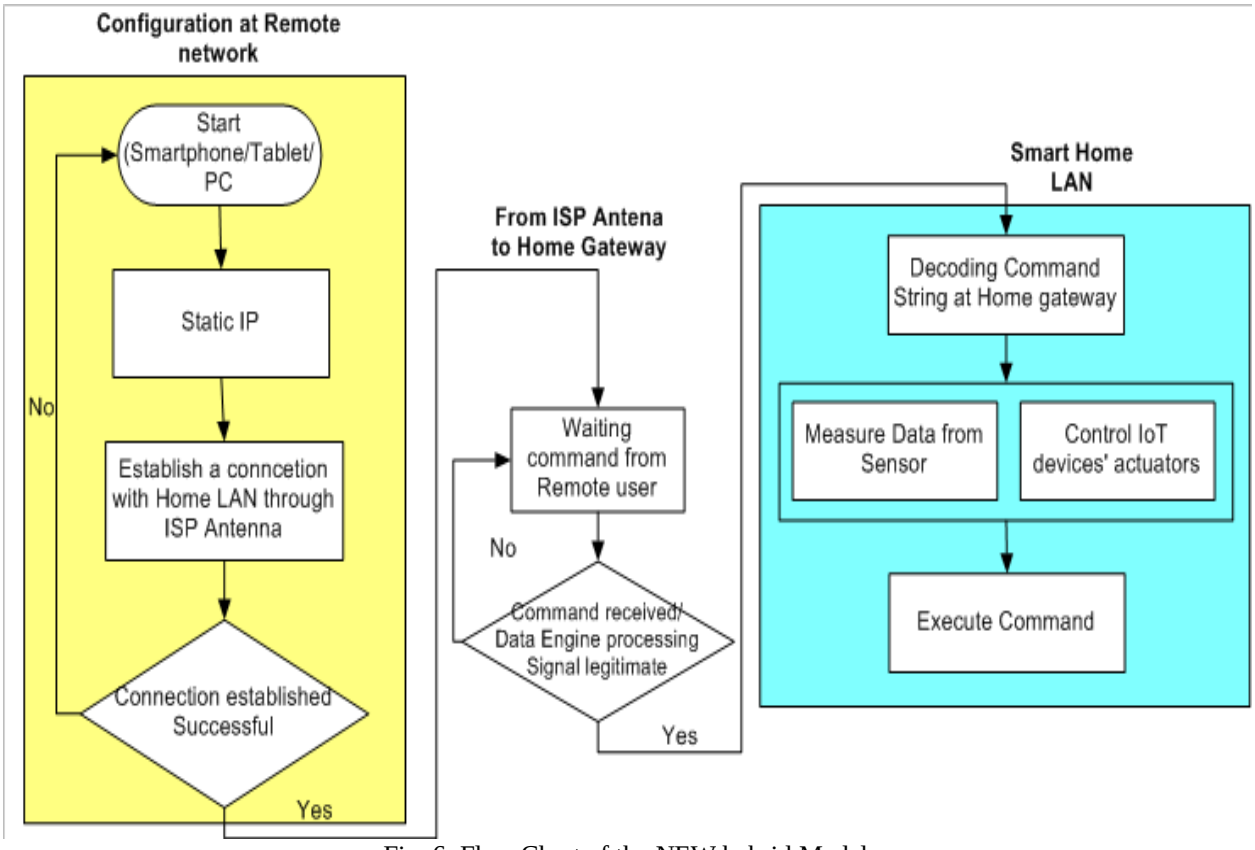

Fig. 6: Flow Chart of the NEW hybrid Model

Below findings from interview conducted with this study's respondents, reveal how the hybrid model should be implemented for a smart home,

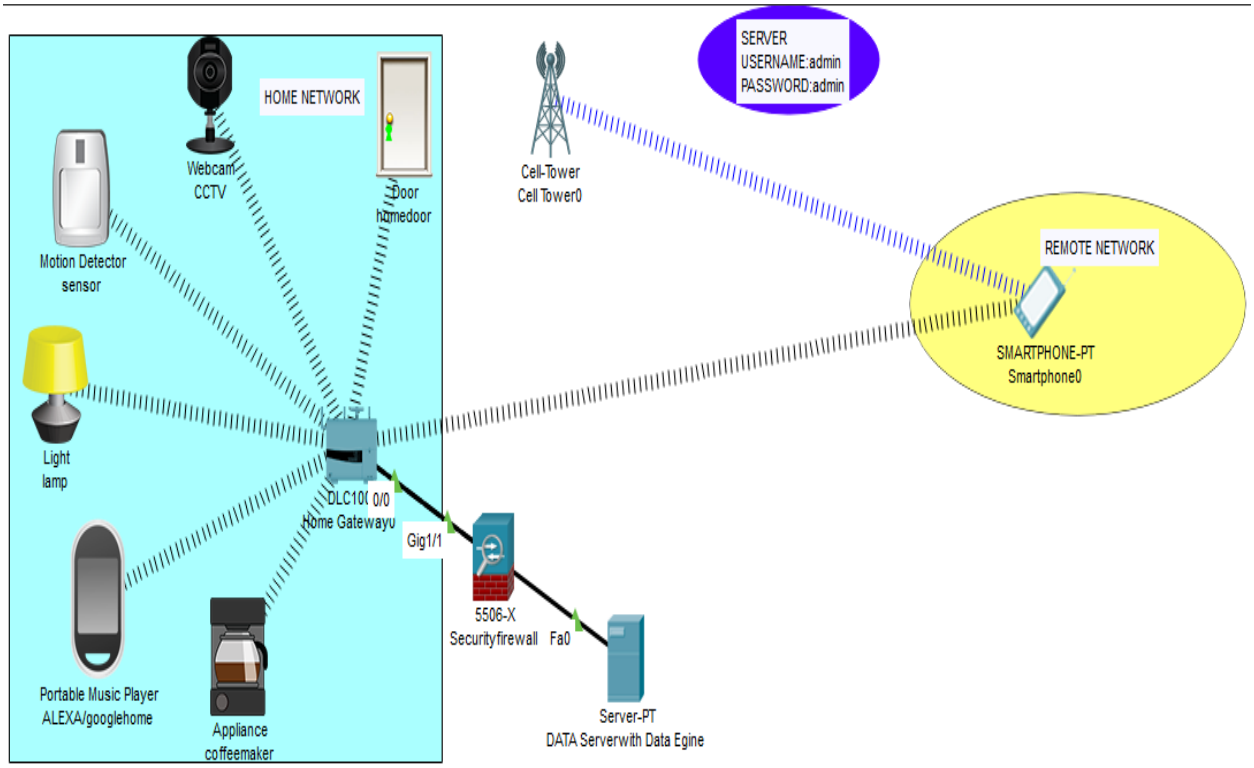

Fig. 7: Hybrid design for Home automation and Remote Monitoring

92% of the respondents revealed that remote connection would be ideal if made through ISP's BSC antenna for guaranteeing availability which can promote anytime anywhere access to the home LAN and provide the easy manipulation and control of the connected IoT devices at home; in addition, it was clarified that connected devices are built with actuators and are centralized to one controller which is based on single board computer at the home gateway.

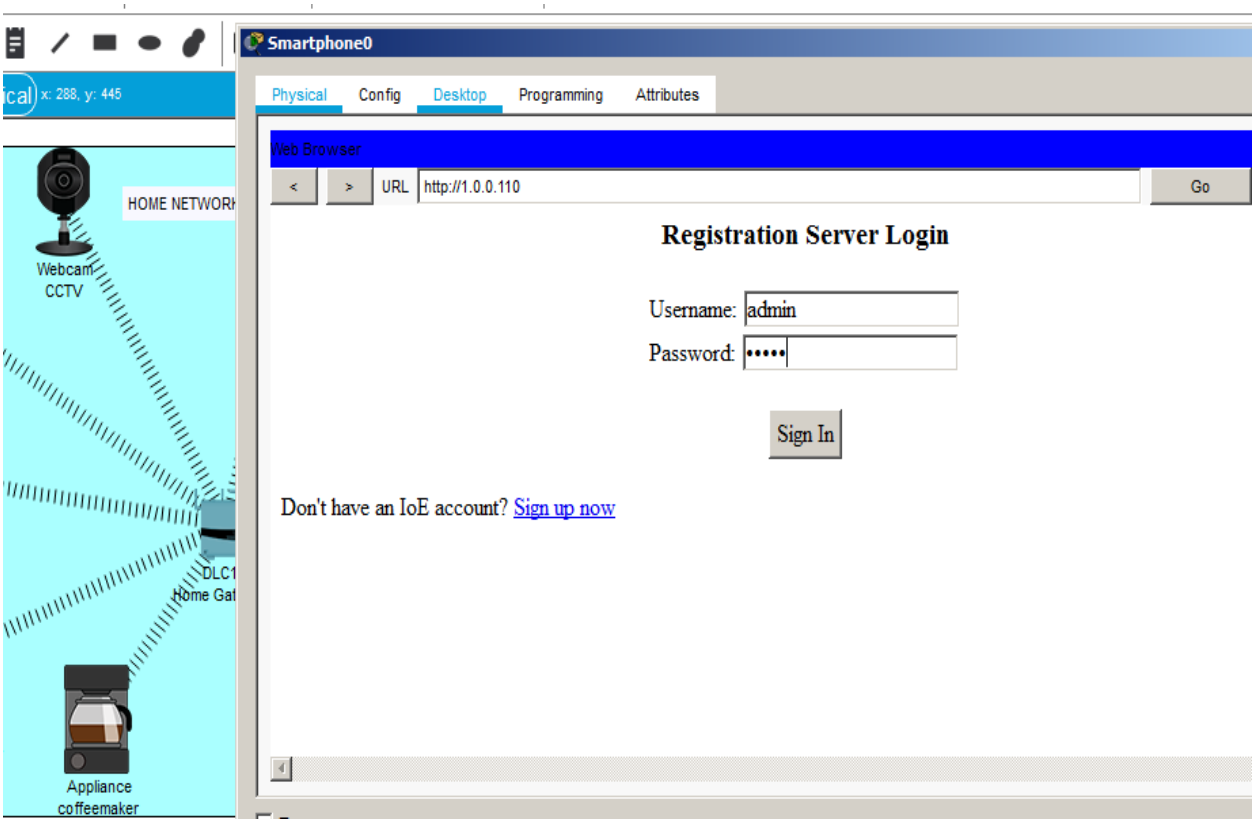

Fig. 8: Securing access with Authentication and Authorization

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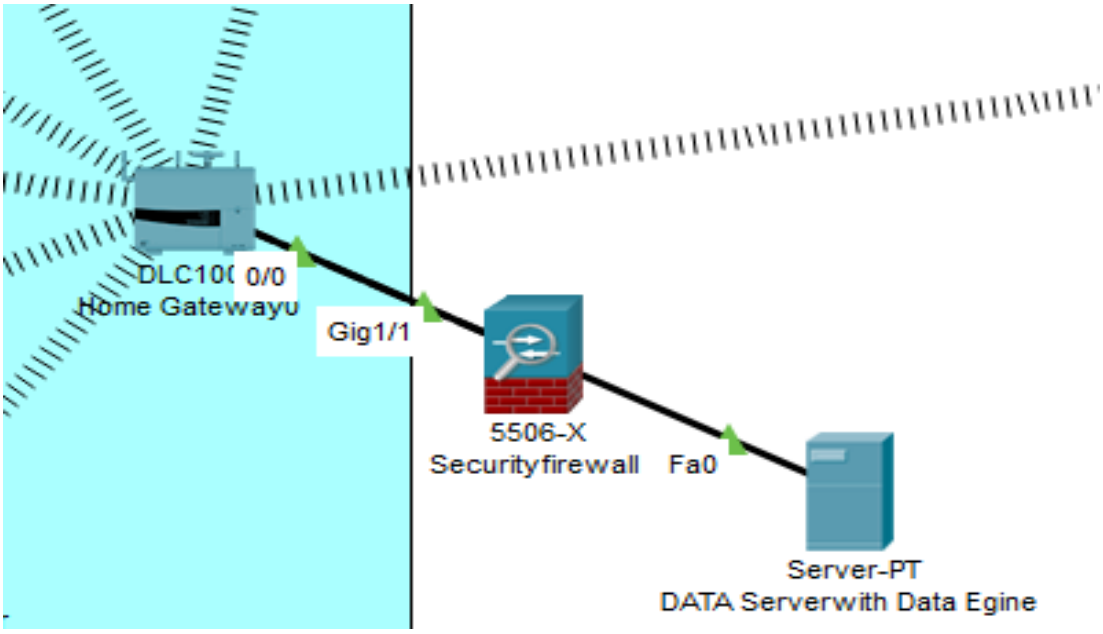

Fig. 9: Security Firewall and Data engine for signal processing and translation

In response to the objective number three which focuses on the design of the hybrid model to address issue of compatibility and security, both figure12 and figure13 reveal technical suggestion from 80% of the respondents for adding security mechanism to prevent unauthorized access and ensure effectiveness in data processing and signal translation for legitimate and accurate commanding the smart home.

The data server with data engine illustration above play an important role in processing data and signals received from the connected devices or remote connection. Without these, one cannot guarantee smooth running of a smart home as desired.

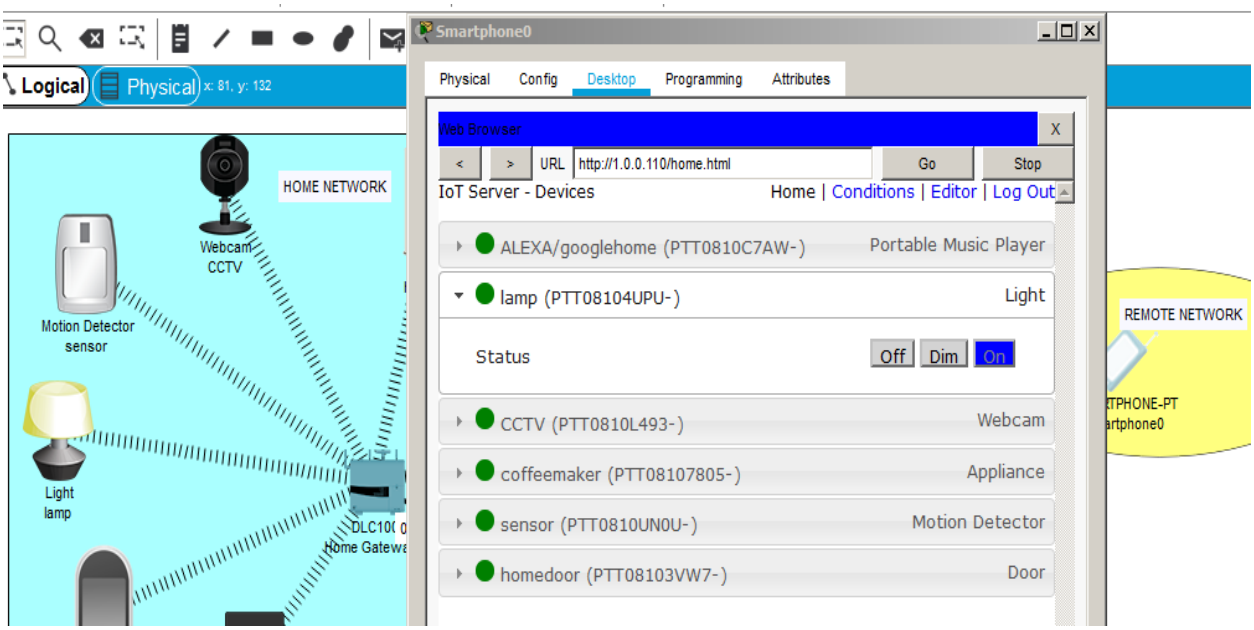

Fig. 10: Remote Access monitoring/manipulating home lamp

As illustration in figure 14, remote connection is established and the authorized remote user is dimming/on/off the home lamp with a simple switch via an API/browser.

Findings revealed by 70% of the respondents, it is very important to promote convenience in remote monitoring of automated whereby one can easily; for example, turn on and off home lamps and other connected devices.

B. Model Testing and remote connectivity, impact analysis

Using Packet tracer simulation at the testing phase of this new proposed model, smart devices were added to Home Gateway using authentication making them discoverable by IoT remote server and from the internet explorer browser researcher was able monitor and manipulate home smart devices remotely. Smart device's state on/off, open/lock, low/high, off/dim was were visible when user logged in the console with right credentials.

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From remote-monitoring devices; this could be a smart phone/table/PC with internet connection, researcher tested the connectivity from remote network to home LAN. The figure below ping results whereby it indicated zero loss of packets, with that being observe, we conclude that the connection is established from LAN network to external network.

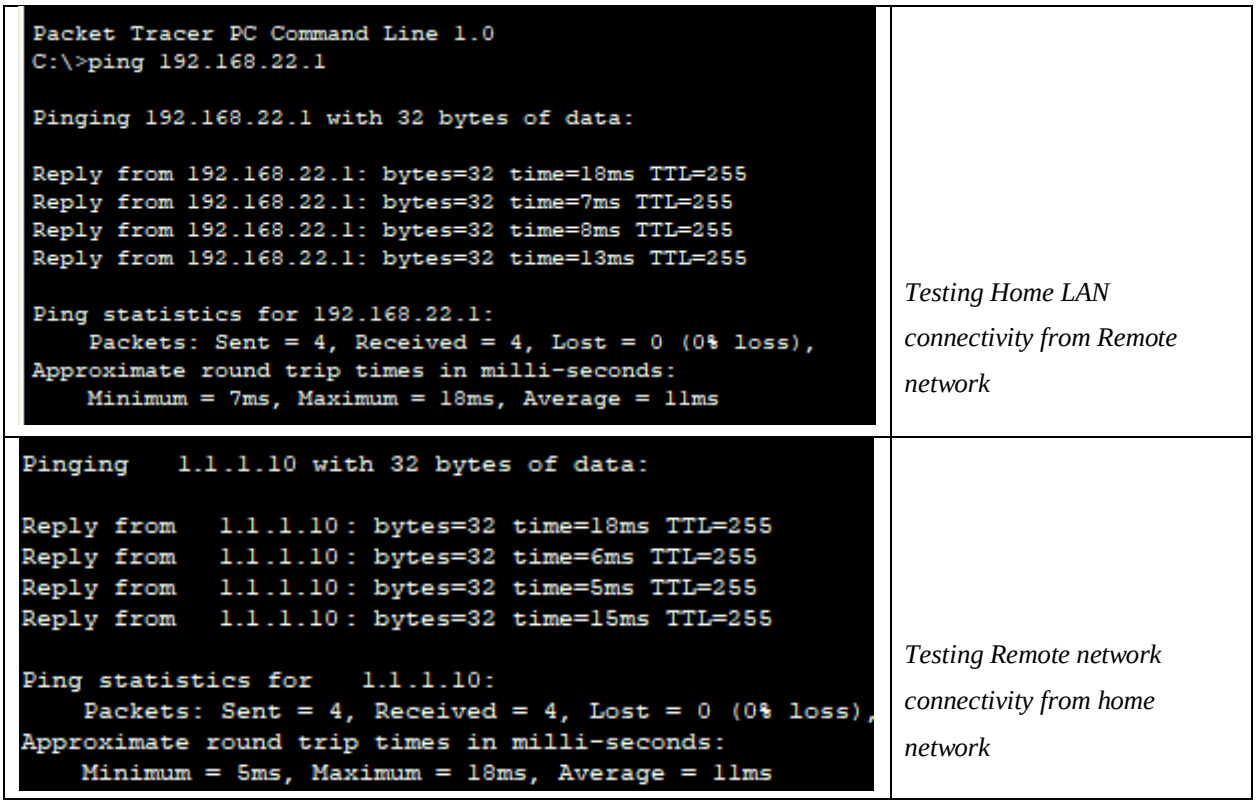

Fig. 11: Connectivity Testing

C. Impact Analysis of IoT technology on smart home

Table 3: Impact analysis of IoT technologies in smart home environment

LIST OF EVENTS					
#	Time	Last Device	At Device	Type	Impact Analysis
1	0.935	Smart Phone/Table/PC	Cloud server	TCP	None
2	0.935	Cloud server	Home gateway	TCP	High
3	0.935	Home gateway	Firewall	TCP	High
3	0.344	Server	Switch	TCP	Positive
4	0.344	Switch	SBC		High
5	0.344	Switch	Access point	TCP	High
6	0.344	SBC	Data Engine	TCP	High
7	0.344	SBC	Alexa	TCP	Positive
8	0.241	Alexa /google home	smart Lamp/Outlet	TCP	Positive
9	0.241	Alexa /google home	Sensors	TCP	Positive
10	0.241	Alexa /google home	Actuators	TCP	Positive
11	0.241	Alexa /google home	CCTV	TCP	Positive

Extracted after the packet tracer simulation for IoT smart home, researcher conducted an impact analysis so as to attend to objective number two which brought about following results.

Event one indicates that a smart Phone/tablet/PC from a remote network has NO impact on a cloud server, the later serves independent whereas the former depends on internet connectivity to establish a remote connection to a smart home network. Findings from impact analysis revealed that access to home gateway through a cloud server has a high impact on the remote access to a smart home network in terms of security (authorization and authentication), and for that matter, a firewall was established with a high impact on the entire home network.

Home gateway has a positive impact on the effectiveness of home network switches and the later has a high impact to smart devices connected to the smart home environment.For wireless bandwidth streaming, an access point is connected to the switch whose impact remain high on the effectiveness of controlling smart devices connected wirelessly.

The SBC (single Board Computer) is feeding from the switch and to this SBC; connected a Data Engine which serves smart home tenants inmaking informed decision after processing events and allow those defined as sensitive in the data engine's algorithm. SBC was analyzed and identified to have a high impact on data engine.

Alexa or google Home are connected via Single Board Computer and this service allows smart home tenants to manipulate connected smart devices while home. With Alexa, a smart Lamp/ IP switch, IP power Outlet, Sensors, Actuators, CCTV and more can be manipulated. Alexa/google home's impact in a smart home was identified to be positive due to its capability of promoting devices compatibility and increasing convenience in a smart home.

V. RECOMMENDATIONS AND CONCLUSIONS

Researcher recommends smart home developers to adapt the proposed model when designing and implementing IoT technologies in the development of smart homes.

Research also recommends home owners to develop interest in smart home with IoT technologies so as to embrace of the benefits of the hybrid model for smart home using IoT technology as discussed in the fourth chapter.

This study was a success in terms of achieving objectives that was set at the beginning of this journey; objectives including but not limited to studying technologies and models currently being used for smart homes with IoT technology, conducting the impact analysis of IoT technology for home automation and remote monitoring and designing a hybrid model for home automation with remote monitoring using IoT technology.

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